EXTRA ARTICULAR DISTAL TIBIAL METAPHYSEAL FRACTURES BY INTRAMEDULLARY INTERLOCKING NAILING-A SHORT TERM ANALYSIS

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ABSTRACT

Fractures of tibia is a controversial subject despite advances in both non-operative and operative care. The treatment should realign the fracture, realign limb length and early functional recovery. Management of distal tibial metaphyseal fractures can be a difficult task. There is relatively little information on their treatment in literaturesfor these fractures are different from proximal diaphyseal fractures and distal intra-articular pilon fractures in terms of the mechanism of injury, treatment principles and prognosis .Treatment varies according to the proximity of the fracture to the plafond, fracture displacement, comminution, and injury to the soft-tissue envelope. surgical fixation like open reduction and internal fixation have been associated with poor results, including soft tissue devitalization, skin slough and infection.Conservative management to avoid these complications has resulted in unacceptable deformity and loss of ankle range of motion to avoid soft tissue complications Minimally invasive surgical techniques have been developed which provides stability and alignment offered with internal fixation.Many techniques have emerged: hybrid external fixation, external fixation with limited internal fixation, percutaneous plate osteosynthesis and intramedullary nailing Intramedullary nailing of open and closed tibial shaft fractures have shown high rates of radiographic and clinical success, but the use of this procedure has not become widely accepted for distal metaphyseal fractures

KEYWORD

Distal tibial metaphyseal fractures, Intramedullary interlocking nailing

ARTICLE HISTORY

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INTRODUCTION

To analyse the short term results of intramedullary interlocking nailing in the management of extra articular distal tibial metaphyseal fractures done in our institution during the period AUGUST 2019 to SEPTEMBER 2021.

REVIEW OF LITERATURE

HISTORICAL REVIEW:

EVOLUTION OF INTRAMEDULLARY NAILING

1875	HEINE	Used ivory pegs in experiments
1875	BARDEHEUER	Ivory pegs clinically
1875	SOCIN	Ivory pegs
1886	BURNS	Ivory pegs
1886	BIRCHER	Reported ivory peg use at German Surgical meet
1902	LEJAHRS	Referred ivory pegs as "nails"
1907	LAMBOTTE	First to use intramedullary metal splints
1916	HEYGROVES	Used solid intramedullary metal rods
1940	GERHARDT KUNTSCHER	Announced intramedullary nailing at Berlin in German Surgical Congress

1942	HABLER	First book on technique of intramedullary nailing published
1942 Kuntscher's intramedullary nailing is the method of future"	LORENZ-BOHLER(Known internationally as the representative of conservative fracture treatment)	At Viennese Medical Society he stated "Intramedullary nailing is the most important contribution to treatment of fractures of long bones.
1945	KUNTSCHER & MEATZ	Published their book
1951	HERZOG	Introduced rigid cloverleaf nail
1961	KUNTSCHER	documented the number of nails sold for treating tibial fractures Availability of reamers, muscle relaxants obviated the need of reduction apparatus and thicker and new nails improved the operative results
1968	KUNTSCHER	At annual meet of German Surgical Society introduced the 'detensor" He introduced the principle of detention to remove harmful forces from frature site and to prevent shortening of bone just before his death. He agreed to change the name to "interlocking nail" since it describes the principle of new nail better
1960-70	KLEMM,SCHELLMANN AND GROSS KEMP	Front runners of current generation of interlocking nails

CLASSIFICATION

Open fractures were classified by **Gustilo and Anderson** in 1976, modified in 1987 which is mostly accepted and quoted throughout the world.

Type I: have less than one cm wound and are due to low energy injury. It usually due to inside out injury due to bone piercing the wound.

Type II: wounds are greater than 1 cm as they are due to high energy injury. The injury is mostly outside in. The amount of soft tissue injury is mild to moderate. Wound closure is mostly possible without SSG or flap cover.

Type III: wounds are due to high energy outside in injuries with wound greater than 10 cms and extensive muscle devitalisation.

Type IIIA- minimal soft tissue and periosteal stripping; soft tissue cover and wound closure will not be a problem.

Type IIIB- extensive soft tissue and periosteal stripping; closure of wound requires a local flap or free tissue transfer.

Type IIIC- open fractures associated with vascular injury where a repair is required for limb salvage.

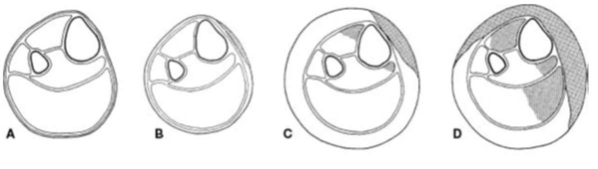
Soft tissue injuries in closed fractures are usually graded by **Tscherne and Gotzen** [26] grading.

Grade 0:little or no soft tissue injury(A).

Grade 1: superficial abrasion with local contusional damage to skin (B)

Grade 2:deep contaminated abrasion with local contusional damage to skin and muscle.©

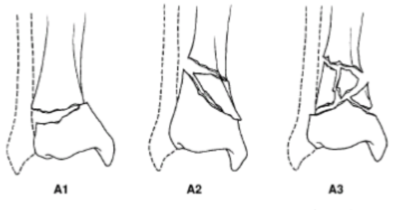
Grade 3:extensive contusion / crushing of skin or destruction of muscle. (D)



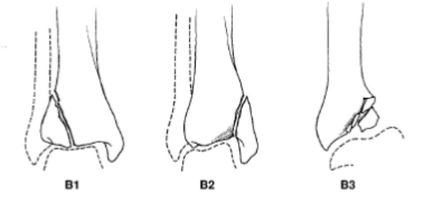
There is no specific classification for Extra articular distal tibial metaphyseal fractures, although studies on this type of fracture commonly use the AO/OTA classification for the fractures of the tibial plafond (segment 43) and the classification by Robinson et al.

The AO/ASIF classification of long bone fractures provides a standardized way to classify fractures which has gained wide clinical acceptance [18].

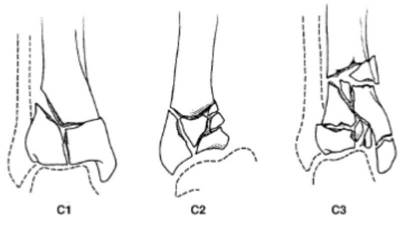
The AO classification system for the fractures of the tibial plafond segment 43 divides articular fractures into three types (A,B,C), each with three main subtypes



Type A Extra-articular
- A1 Metaphyseal simple
- A2 Metaphyseal wedge
- A3 Metaphyseal complex



Type B Partial articular
- B1 Pure split
- B2 Split depression
- B3 Multifragmentary depression



Type C Complete articular
- C1 Simple articular with simple metaphyseal fracture
- C2 Simple articular with multifragmentary metaphyseal fracture
- C3 Articular multifragmentary

BIOMECHANICS OF IM NAIL

IM nails act as internal splints with load-sharing characteristics. The amount of load borne by the nail depends on the stability of the fracture/implant construct. This stability is determined by nail size, number of locking screws or bolts, and distance of the locking screw or bolt from the fracture site[2].

In current practice, with reaming of the canal and the use of locking screws, physiologic loads are transmitted to the proximal and distal ends of the nail through the screws. Fluting of the nail can increase its torsional friction within the medullary cavity. Three types of load act on an IM nail: torsion, compression, and tension. Physiologic loading is a combination of all three. When cortical contact across the fracture site is achieved postoperatively, most of the compressive loads are borne by the bony cortex; however, in the absence of cortical contact, compressive loads are transferred to the interlocking screws, which results in four-point bending of the screws[2].

BIOMECHANICS OF INTERLOCKING SCREW/BOLT

Interlocking screws placed proximal and distal to the fracture site restrict translation and rotation at the fracture site; however, minor movements occur between the nail and screws, allowing toggling of the bone.

The stability depends on the locking screw or bolt diameter for a given nail diameter. Nail hole size should not exceed 50% of the nail diameter. Interlocking screws undergo four point bending loads, with higher screw stresses seen at the most distal locking sites. The location of the distal locking screws affects the biomechanics of the fracture, but the effect of the orientation of the locking screws is less clear. Oblique or transverse orientation of the distal screws in distal-third tibia fractures has minimal effect on stability .To maintain optimal alignment in nondiaphyseal fractures, care should be taken to direct the nail into the center position of both fragments.In addition, multiple locking screws should be used in the metaphyseal fragment. Tibial nail designs can have very distal and proximal locking sites as well as multiplanar locking options for the fixation of proximal and distal metaphyseal fractures.

OPERATIVE PROCEURE

POSITION OF THE PATIENT

In standard technique for interlocking nailing fracture table is used. Patients positioned supine with hip flexed to 45 degrees and knee flexed to 90 degrees under calcaneal pin traction. Alternatively, patient may be positioned supine on the ordinary table with the knees hanging down the end of the table. Patient may also be positioned supine on the ordinary table and the knee kept in flexion with pillow under the knee.

FRACTURE REDUCTION

Fracture can be reduced by the traction through the calcaneal pin when fracture table is used or manual traction and manipulation can be given when standard table is used usually under C-arm control. A femoral distractor or a fibular plating can also be used to reduce and align the fracture.

ENTRY POINT

Patellar tendon splitting approach:

A vertical incision from tuberosity to the lower end of the Patella is made. Patellar tendon is exposed and split in the middle. Entry point is made with awl, proximal to tibial tubercle approximately 1.5 cm distal to joint line and in line with the center of the medullary canal on the AP view.

Medial Parapatellar approach;

Here incision is made from middle of the medial border of patella to tibial tuberosity. Patellar tendon is exposed and retracted laterally. Entry point is made similar to the previous approach.

REAMING, NAIL INSERTION AND LOCKING

After entry point is made ball tipped guide wire is passed under Carm. Guide wire should be in center of the distal fragment on both views and advanced to within .5 mm to 1 cm of ankle joint. Then serial is reaming done in .5 mm increments. Then flexible Teflon sleeve is passed over the wall tipped guide wire. Then wall tipped guide wire is exchanged for a smooth tip wire for nail insertion.

Length of the nail determined by (Fluoroscopic measurement):

1. With the help of graduated guide wire.
2. Subtraction of the exposed guide wire from the total length of the guide wire.
3. Using radiopaque ruler and measuring distance between anterior edge of the entry portal to a point 0.5 to 1 cm proximal to ankle join.

Nail diameter is selected 1 mm less than the last reamer used. Now the appropriate nail mounted in the Jig and it is inserted over the guide wire under C-arm control. The distal tip of the nail should lie approximately 0.5 to 2 cm from the subchondral bone of the ankle joint. Now the traction is released to allow impaction of the fracture. Proximally counter sinking of nail is done up to 0.5 to 1 cm. Distal locking is done under C-arm control as free hand technique. The number and orientation of the distal locking bolts were made at the surgeon's discretion. In general 2 medial to lateral locking bolts were preferred. Proximal locking is done with Jig. Before insertion of proximal locking fracture site is checked and if it is distracted reverse jamming is done.

MATERIALS AND METHODS

This study was designed to review the outcomes of the treatment of extraarticular distal tibial metaphyseal fractures by intramedullary interlocking nailing.

From August 2019 to September 2021, 28 consecutive extraarticular distal tibial metaphyseal fractures in skeletally matured patients managed by primary locked intramedullary nailing. Inclusion criteria were, fracture sustained within the past 1 week, skeletal maturity, fracture center in the distal metaphysis of tibia involving the distal 5 cm , associated fibular fracture and treatment with an intramedullary nail of the fracture pattern that allowed placement of atleast 2 distal interlocking screws through the nail. Patients with neglected fractures (more than 3 weeks), non union, and patient with multiple injuries or a history of previous knee or ankle pathology were not included as were patients who sustained high energy axial load injury causing disruption or impaction of the ankle plafond. There were 24 men and 4 women with a mean age of 33 years (19 to 55). All fractures were classified by the AO system (Muller et al 1990), and the classification by Robinson et al. The severity of the soft-tissue injury in the open fractures was recorded on the Gustilo system and closed fractures were recorded on the Tscherne system. Biplanar injury radiography was evaluated to determine the fracture location and involvement of the distal part of the tibia by applying AO system of rule of squares. In all cases the fracture extended to within 5.5 cm of the ankle joint and there was associated fibular fracture. Low energy motor vehicle accident and fall from height causing a torsional or bending force was the mechanism of injury in majority of the patients.

All the fractures were treated with a primary reamed intramedullary nailing system that increased the distal fixation with up to 3 biplanar distal interlocking screws passing through the distal 4 cm of the nail. The surgery was done using a standard radiolucent table under c- arm guidance with manual traction alone. The decision for adjunctive fibular stabilisation as well as the number and orientation of the distal locking bolts were made at the surgeon's discretion. In general 2 medial to lateral locking bolts were preferred. Open reduction of the fracture was done in 8 patients. Patients suffering from open fractures underwent debridement and primary closure followed by stabilisation. Closed fractures were initially managed by reduction and application of splint followed by operative treatment to decrease the soft tissue swelling. All patients were given I.V third generation cephalosporin during induction wich was continued for 3-5 days post operatively. The average time from the moment of injury to the operative fixation of fracture was 12 days (range 6 hrs to 20 days)

POST OP PROTOCOL AND FOLLOW UP:

All patients followed the same postoperative protocol. The leg was initially placed in a splint for forty-eight to seventy-two hours. Post operative antero-posterior and lateral X-rays were taken and analysed for alignment, locking and stability of the fixation. All patients were encouraged to begin an early active range of motion of the ankle and knee as tolerated.

Sutures were removed on the twelfth post operative day. A detachable brace was then applied, if the patient was thought to be able to comply with the postoperative protocol. Patients who were thought to be unable to follow postoperative instructions wore a short leg cast for the initial four weeks. Patients were not allowed to bear full weight for four weeks. All patients were reviewed by a single observer. Clinical assessment included time to full weight bearing, return to work, presence of anterior knee pain and limb length and rotation. Ankle motion was recorded and all patients were scored using the IOWA ankle evaluation system.Radiographs were reviewed monthly for fracture union and to assess limb alignment. The alignment was assessed by constructing longitudinal line from the mid point of the medial and lateral cortices (on anterior- posterior X ray) for varus – valgus measurement and mid point of the anterior and posterior cortices (on lateral X rays) for recurvatum – procurvatum measurement .Bony union was defined as evidence of bridging callus across the fracture site or the obliteration of the fracture lines based on the X ray findings. Malunion was defined as varus / valgus deformity, anterior/posterior angulations, or rotational deformity of more than 10 degrees or shortening of more than 1 cm [25]. Delayed Union was defined as the failure to see evidence of union on radiographs at various time-points ranging from twenty to twenty-six weeks.

IOWA ANKLE EVALUATION SCORE

Function: (40)

- Does housework or job without difficulty (8)
- Climbs stairs (10)
- Carries heavy objects, such as a suitcase (4) ___/40
- Is able to run, or work at heavy labour(4)
- Walks enough to be independent(8)
- Does yard work, gardening, lawn mowing (4)
- Has no difficulty getting in or out of an automobile (6)

Freedom from pain: (40)

- No pain (40)
- Pain only with fatigue or prolonged use (30) ___/40
- Pain with weight-bearing (20)
- Pain with motion (10)
- Pain with rest or continuous pain (0)

Gait:(10)

- No limp (10)
- Antalgic limp (8) ___/10
- Uses cane or one crutch (2)
- Uses wheelchair or can't walk (0)

Range of motion(10)

- Dorsifiexion and plantar flexion ___/10
- (2 Points for every 20 degrees)

TOTAL SCORE : ___/100

Excellent : 100 - 90
Good : 89 - 80
Fair : 79 - 70

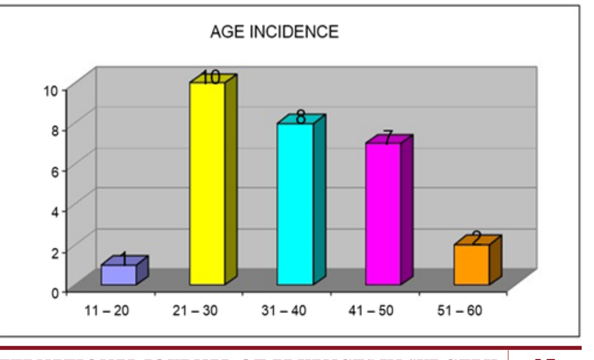
OBSERVATION

The following observations were made in the study.

AGE INCIDENCE:

Patients' age ranged from 19 to 55 years. Average: 32.

Age in yrs	No. of Patients
11 – 20	1
21 – 30	10
31 – 40	8
41 – 50	7
51 – 60	2
TOTAL	**28**



SEX INCIDENCE:

In our series, Male predominated with the ratio of 6:1.

Sex	No. of Patients
Male	24
Female	4

SIDE:

In our series, Right side was more common

SIDE	No. of Patients
Right	18
Left	10

FRACTURE CLASSIFICATION:

In our study, eight fractures were open: five were classified as Gustilo type I and three as type II. Of the remaining closed fractures fourteen were classified as Tscherne type I and six as type II.

FRACTURE TYPE No. of Patients

FRACTURE TYPE		No. of Patients
Open	Gustilo type I	5
	Gustilo type II	3
Closed	Tscherne type I	14
	Tscherne type II	6

AO/OTA CLASSIFICATION:

According to AO/OTA guidelines, there were sixteen 43A1, nine 43A2 and three 43A3 fractures.

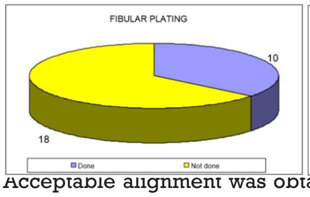
AO/OTA Type	No. of Patients
43 A 1	16
43 A 2	9
43 A 3	3

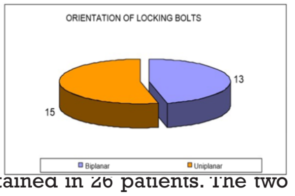
FRACTURE CONFIGURATION:

Type of Tibia Fracture	Level Of Fibula Fracture	No. of Patients
Transverse	Same level	9
	Proximal level	6
Oblique	Same level	4
	Proximal level	2
Comminuted	Same level	5
	Proximal/Segmental	2

RESULTS

The mean follow up was 14 months (range 3m to 26 m). The average distance from the distal extent of the tibial fracture to the plafond was 4.8 cm (range, 4.2 cm to 5.8 cm). The average distance between the distal tip of the nail and the articular surface of the plafond was 12 mm (range, 4 to 15 mm). The decision for adjunctive fibular stabilisation as well as the number and orientation of the distal locking bolts were made at the surgeon's discretion. Fibular plating was done in 10 patients. Two distal locking bolts were used in 26 patients; 2 patients had three distal locking bolts.





Acceptable alignment was obtained in 26 patients. The two patients who had immediate malalignment in the form of 10° valgus deformity had transverse fracture of tibia with same level fibular fracture (AO43A1 & Robinson type 1). In both the cases fibula was not stabilized. One patient underwent corrective surgery with fibular plating and the other patient denied surgery and was eventually lost for follow up. In total out of the 28 patients in our study, two were lost to follow-up. Out of the remaining 26 patients, 25 had radiographic evidence of healing at the time of follow-up. The mean time for union was 19 weeks (range 12 – 26 weeks). The mean IOWA ankle functional assessment score was 82 (good) (range 68-94) Of the two patients who were lost to follow-up, one had comminuted fracture with segmental fibular fracture and the other had transverse fracture with same level fibula fracture. The fracture patterns and immediate postoperative alignment in these patients were not significantly different from those in the remaining. Eight patients had change in the final alignment in either the coronal or the sagittal plane compared with the alignment on the immediate postoperative radiographs. All the 8 patients had 2 distal locking bolts without fibular stabilization. The clinical and demographic details of these patients are given in the table.

Gender		
Male	7	
Female	1	
Fracture type		
Open (Gustilo)	Type 1	2
	Type 2	1
Closed(Tscherne)	Type 1	3
	Type 2	2
Fracture classification		
AO/OTA	43 A1	4
	43 A2	2
	43A3	2
Robinson	Type I	6
	Type IIA	2
Fracture configuration		
Transverse	4	
Oblique	2	
Communited	2	
Location of fibula fracture		
Same level	7	
Different level	1	
Locking bolts		
2 Medio-lateral	**5**	
1 Anterio-posterior & 1 Medio-lateral	**3**	
Distance of the fracture from ankle joint	4.6 cm (Avg)	
Type of Malalignment	Valgus angulation 10° : 4 Patients Varus angulation 10°: 2 patients Valus with recurvatum: 2 patients	

Other complications included one superficial infection, one deep infection at the site of fracture, one delayed union and four patients of anterior knee pain. The superficial infection responded to local debridement and intravenous administration of antibiotics. In the patient with deep infection, the fibula was united and the patient underwent nail removal with posterolateral bone grafting which went on to heal uneventfully. No bone-grafting procedures were required to obtain union in any patient. The patient with delayed union underwent dynamization procedure. Anterior knee pain was managed conservatively.

CASE ILLUSTRATION: 1 : Mr. N (PATIENT: 3)

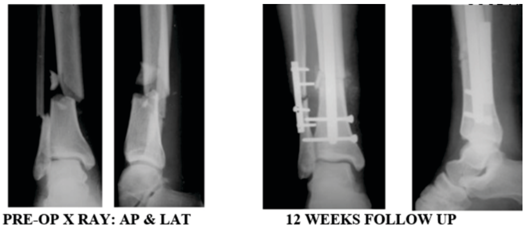
PRE-OP X RAY : AP & LAT 14 WEEKS FOLLOW UP ROM AT 16 WEEKS

CASE ILLUSTRATION: 2

- NAME : Mrs.C (Patient No:6)
- AGE/GENDER : 50/F

- I.P.No :859012
- MODE OF INJURY :RTA
- NATURE OF INJURY :Closed Ischernic Type I
- DISTANCE FROM PLAFOND :4.2 cm
- CLASSIFICATION
- AO : 43A2
- ROBINSON :II A
- TYPE :Communited fracture of tibia with
- Same level fibular fracture
- DISTAL SCREW ORIENTATION:Uni planar
- FIBULAR PLATING :Done
- MALUNION ON FOLLOW UP :NIL
- TIME TO UNION : 18 weeks
- IOWA SCORE :90
- COMPLICATION :NIL

CASE ILLUSTRATION: 2: Mrs. C (PATIENT: 6)



PRE-OP X RAY: AP & LAT 12 WEEKS FOLLOW UP

RANGE OF MOVEMENTS AT 18 WEEKS

DISCUSSION

Treatment principles for extraarticular distal tibial metaphyseal fractures are different from and must be distinguished from those for both proximal diaphyseal fractures and distal intra-articular pilon fractures. Muller defined the distal tibial metaphysis by constructing a square, with the sides of length defined by the widest portion of the tibial plafond. In our review, we considered fractures within 5.5 cm of the tibial plafond without extension to the plafond to be distal metaphyseal fractures.The major difficulty in selecting candidates for intramedullary fixation of a distal tibial fracture is in differentiating low energy tibial fractures from axial high energy loading injuries with or without primary articular involvement [7,8]. Published studies often include fractures with intra articular extension and they utilize AO/OTA classification of tibial pilon fractures for classification which is inadequate, does not address the fibula and does not differentiate high energy axial load fractures with low energy extra articular fractures. Nailing of extra articular distal tibia fractures is challenging, technically demanding and should be approached with caution [8]. Apart from malalignment which is recognized in the immediate postoperative period, primarily due to difficulty in controlling the short distal fragment and technical errors, loss of reduction can occur during the follow up due to unrecognized instability [9]. Though critical surgical tenets such as central placement of the guide wire and reamers, maintenance of the reduction at the time of nail passage and placement of nail in subchondral region, are described to avoid intraoperative malalignment [33], very few studies explore the causes and prevention of loss of reduction during follow up [7].Therefore excluding patient related causes for late malalignment, the two major factors which appear to affect the fracture construct stability are adjunct fibular stabilization and the number and orientation of the distal locking bolts [21].Kumar et al [17] reported on the effect that fibular plating of the same level tibia-fibula fractures has on the rotational stability of distal tibial fractures treated with an IM nail. Fibular plate reduced axial rotation by approximately 1.5 deg when a torque of 1 to 5 N was applied to the proximal end of the tibia. Another study by Morrison et al [39] in cadavers found that plating the fibula improved resistance to deformation in axial loading by a factor of 2.2.

A clinical retrospective study, by Egol et al ,.that was conducted at three level-I trauma centers, two groups of fractures were studied. In multivariate adjusted analysis, plating of the fibular fracture was significantly associated with the maintenance of reduction. The authors found that the use of at least two distal locking bolts also was protective against the loss of reduction. Two distal locking bolts certainly adds strength to fracture stability but there is some discrepancy in the literature regarding its orientation on fracture construct stability

Chen et al The authors found that there was no differences in angulation, rotation or translation of the distal fragment whether the locking bolts were placed in parallel or perpendicular to one another after cyclic loading of the fragments.This is in contrast to the study by Smuker et al which found a significant difference in stability between constructs locked with bolts in parallel versus those placed perpendicular with 2 parallel locking bolts being a better construct. Our study had both types of constructs; both had failure to maintain alignment.

Many studies stress the importance of obtaining and maintaining a reduction of distal tibial fractures with stable fixation allowing for early rehabilitation. But till now there have been no prospective, randomized trials on the types of treatment of this injury.Limitations in this study include its retrospective design, the small number of patients, the fact that multiple surgeons participated in the treatment, and the nonstandardized radiographic assessments.The role of fibular plating with nailing must be determined on an individual basis depending upon the fracture pattern. To our knowledge no distal tibial fracture classification in English literature specifically addresses concurrent fibular fracture fixation. Based on our experience we found that the two discrete groups of injuries with different mechanisms as described by Robinson et al produced three common fracture configurations. We propose a new classification for extra articular distal tibial metaphyseal fractures which takes into the associated fibular fracture and addresses its stabilization.

CONCLUSION

Intramedullary nailing is a safe and effective technique for the treatment of extra articular distal metaphyseal tibial fractures if careful preoperative planning is allied with meticulous surgical technique. Acceptable alignment of the short distal fragment during surgery is necessary for good functional outcome. Knowledge and recognition of inherent instability of the short distal fragment is necessary to enable stable fixation and avoid loss of reduction on follow up. We propose a new classification to aid stable fixation of the distal fragment by fibular plating.

Prospective, randomized, clinical trials are needed to determine the outcomes of metohods of internal fixation in the management of extra articular distal metaphyseal tibial fractures.

Study	Fracture Type	Surgical Technique	Outcome (Union)
Robinson et al	63 distal metaphyseal (10 open, 53 closed)	63 reamed, locked IM nail; 2 distal interlocking screws	59 primary union; 4 healed with secondary procedures Mean 16.2 weeks

Konrath et al	20 distal tibia (5 open, 15 closed)	Lag screw ± plate fixation;locked IM nail	19 primary union; 1 secondary procedure Mean 17 weeks
Fan et Al	20 distal tibia (5 open, 15 closed)	locked IM nail; 2 or 3 distal interlocking screws	All united at 17.2 weeks
Nork et al	36 distal tibia metaphyseal fractures, 6 with articular extension	Lag screw ± plate fixation locked IM nail	Primary union in 33 patients Mean 23.5 weeks
Our study	26 distal tibia metaphyseal fractures	locked IM nail; 2 or 3 distal interlocking Screws. plate fixation of fibula	All united Mean time : 19 weeks

REFERENCES

1. Alberts KA, Loohagen G, Einarsdottir H. Open tibial fractures: faster union after unreamed nailing than external fixation. Injury. 1999;30:519
2. Bechtold JE, Kyle RF, Perren SM: Biomechanics of intramedullary nailing, in Browner B, Edwards C (eds): The Science and Practice of Intramedullary Nailing. Philadelphia, PA: Lippincott Williams and Wilkins, 1987,pp 89-101
3. Blachut PA, O'Brien PJ, Meek RN, Broekhuyse HM: Interlockin intramedullary nailing with and without reaming for the treatment of closed fractures of the tibial shaft: A prospective, randomized study. J Bone Joint Surg Am 1997;79:640- 646.
4. Borrelli J Jr, Prickett W, Song E, Becker D, Ricci W: Extraosseous blood supply of the tibia and effects of different plating techniques: A human cadaveric study. J Orthop Trauma 2002;16:691-695.
5. Bourne RB: Pylon fractures of the distal tibia. Clin Orthop Relat Res 1989;240:42-46.
6. Chen AL, Tejwani NC, Joseph TN, Kummer FJ, Koval KJ: The effect of distal screw orientation on the intrinsic stability of a tibial intramedullary nail. Bull Hosp Jt Dis 2001;60:80-83.
7. Dogra AS, Ruiz AL, Thompson NS, et al. Dia-metaphyseal distal tibial fractures: treatment with a shortened intramedullary nail: a review of 15 cases. Injury. 2000;31:799–804.
8. Fan CY, Chiang CC, Chuang TY, Chiu FY, Chen TH. Interlocking nails for displaced metaphyseal fractures of the distal tibia. Injury. 2005 May;36(5):669-74.
9. Freedman EL, Johnson EE. Radiographic analysis of tibial fracture alalignment following intramedullary nailing. Clin Orthop 1995;315:25-33
10. Goh JC, Mech AM, Lee EH, Ang EJ,Bayon P :Biomechanical study on the load-bearing characteristics of the fibula and the effects onzibular resection. Clin Orthop Relat Res 1992;279:223-228.
11. Gorczyca JT, McKale J, Pugh K, Pienkowski D: Modified tibial nails for treating distal tibia fractures. J Orthop Trauma 2002;16:18-22.
12. Gustilo RB, Anderson JT: Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: Retrospective and prospective analyses. J Bone Joint Surg Am 1976;58:453-458
13. Keating JF, O'Brien PJ, Blachut PA, Meek RN, Broekhuyse HM:Locking intramedullarynailingwith and without reaming for openfractures of the tibial shaft: A prospective, randomized study. J Bone joint Surg Am 1997;79:334-341.
14. KneifelT, Buckley R:Acomparison of one versus two distal locking screws in tibial fractures treated with unreamed tibial nails. A prospective randomized clinical trial. Injury 1996;27:271-273
15. Konrath G, Moed BR, Watson JT,Kaneshiro S, Karges Intramedullary nailing of unstable diaphyseal fractures of the tibia with distal intraarticular involvement.J Orthop Trauma 1997;11:200-205
16. Krettek C, Stephan C, Schandelmaier P, RichterM, Pape HC, Miclau T: The use of Poller screws as blocking screws in stabilising tibial fractures treated with small diameter intramedullary nails. J Bone Joint Surg Br 1999;81:963-968.
17. Kumar A, Charlebois SJ, Cain EL, Smith RA, Daniels AU, Crates JM:Effect of fibular plate fixation on rotational stability of simulated distal tibial fractures treated with intramedullary nailing. J Bone Joint Surg Am2003;85:604-608
18. Martin JS, Marsh JL, Bonar SK, De-Coster TA, Found EM, Brandser EA: Assessment of the AO/ASIF fracture classification for the distal tibia. J Orthop Trauma 1997;11:477-483.
19. Mast J, Jakob R, Ganz R: Planning and Reduction Technique in Fracture Surgery. New York, NY: Springer-Verlag, 1989.
20. Merchant TC, Dietz FR. Long-term follow-up after fractures of the tibial and fibular shafts. J Bone Joint Surg Am. 1989;71:599-605.
21. Morrison KM, Ebraheim NA, Southworth SR, Sabin JJ, Jackson WT. Plating of the fibula. Its potential value as an adjunct to external fixation of the tibia. Clin Orthop. 1991;266:209-13.
22. Mosheiff R, Safran O, Segal D, Liebergall M:The unreamed tibial nail in the treatment of distal metaphyseal fractures. Injury 1999;30:83-90.
23. Müller ME, Allgöwer M, Schneider R, Willenegger H. Manual of Internal Fixation, 3rd ed. Heidelberg, Springer-Verlag, 1991.
24. Muller ME, Nezarian S, Koch P, Schatzker J: The Comprehensive Classification of Fractures of Long Bones. Berlin, Germany: Springer- Verlag, 1990.
25. Nork SE, Schwartz AK, Agel J, Holt SK, Schrick JL, Winquist RA. Intramedullary nailing of distal metaphyseal tibial fractures. J Bone Joint Surg Am. 2005 Jun;87(6):1213-21
26. Oestern HJ, Tscherne H: Pathophysiology and classification of soft tissue injuries associated with fractures, in Tscherne H, Gotzen L (eds): Fractures With Soft Tissue Injuries. Berlin, Germany:Springer- Verlag, 1984, pp 6-7
27. Oh CW, Kyung HS, Park IH, Kim PT, Ihn JC. Distal tibia metaphyseal fractures treated by percutaneous plate osteosynthesis. Clin Orthop Relat Res.2003;408:286-91
28. Ovadia DN, Beals RK. Fractures of the tibial plafond. J Bone Joint Surg [Am] 1986;68-A:543-5 1.
29. Richter D, Ostermann PA, Ekkernkamp A, Hahn MP, Muhr G: Distal tibial fracture: An indication for osteosynthesis with an unreamed intramedullary nail?Langenbecks Arch Chir Suppl Kongressbd 1997;114:1259-1261.
30. Robinson CM, McLauchlan GJ, McLean IP, Court-Brown CM.Distal metaphyseal fractures of the tibia with minimal involvement of the ankle. Classification and treatment by locked intramedullary nailing. J Bone Joint Surg Br. 1995;77:781-7.
31. Rüedi TP, Allgöwer M: The operative treatment of intra-articular fractures of the lower end of the tibia. Clin Orthop 1979;138:105-110.
32. Rüedi TP, Allgöwer M: Fractures of the lower end of the tibia into the ankle-joint. Injury 1969;1:92-99.
33. Russell GV Jr, Pearsall AW IV: Intramedullary nailing of distal tibia fractures: A technique to prevent malalignment. Orthopedics 2003;26:183-185.
34. Sarmiento A, Gersten LM, Sobol PA, Shankwiler JA, Vangsness CT. Tibial shaft fractures treated with functional braces. Experience with 780 fractures. J Bone Joint Surg Br. 1989;71:602-9.
35. Sarmiento A, Latta LL: 450 closed fractures of the distal third of the tibia treated with a functional brace. Clin Orthop Relat Res 2004;428:261-271
36. Schemitsch EH, Kowalski MJ,Swiontkowski MF, Harrington RM: Comparison of the effect of reamed and unreamed

locked intramedullary nailing on blood flow in the callus and strength of union following fracture of the sheep tibia. J Orthop Res 1995; 13:382-389

37. Trafton PG: Tibial shaft fractures, inBrowner BD, Levine AM, Jupiter JB (eds): Skeletal Trauma, ed 3. Philadelphia,PA:WB Saunders, 2003, vol 2, pp2131-2256.
38. Triffitt PD, Cieslak CA, Gregg PJ: A quantitative study of the routes of blood flow to the tibial diaphysis after an osteotomy. J Orthop Res 1993;11:49-57.
39. Weber TG, Harrington RM, Henley MB, Tencer AF. The role of fibular fixation in combined fractures of the tibia and fibula: a biomechanical investigation. J Orthop Trauma. 1997;11:206-11.
40. Yang SW, Tzeng HM, Chou YJ, Teng HP, Liu HH, Wong CY. Treatment of distal tibial metaphyseal fractures: Plating versus shortened intramedullary nailing. Injury. 2006 Jan 10;